CAN THE ALASKA SALMON FISHERIES BE SAVED?

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THERE are, in Alaskan waters, five species of salmon, all belonging to the genus *Oncorhynchus*. They are (1) the King, Chinook, Quinnat, or Spring Salmon (*Oncorhynchus tschawytscha*); (2) the Sockeye, Red, or Blueback Salmon (*O. nerka*); (3) the Coho, Silver, or White Salmon (*O. kisutch*); (4) the Humpback, or Pink Salmon (*O. gorbuscha*); and (5) the Dog, or Keta Salmon (*O. keta*). The Steelhead Trout (*Salmo gairdneri*) also occurs in Alaska where it is usually classed as a salmon by the commercial fishermen.

Each of these six species is more or less abundant in Alaska and all are the objects of important commercial fisheries.

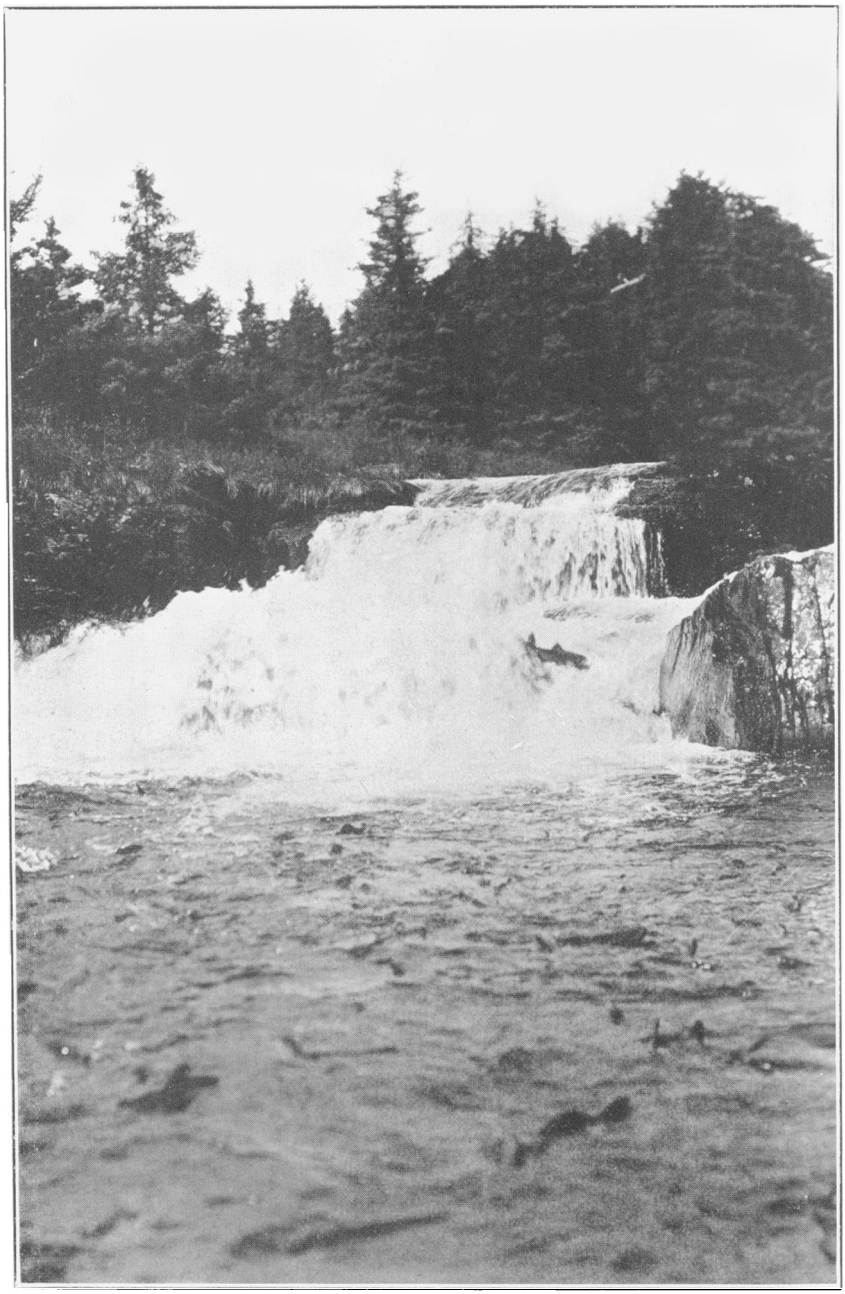
Habits of the Pacific Salmon

The habits of all the different species of Pacific salmon are essentially the same. They are all anadromous; that is, they live most of their life in the sea and enter fresh water only to deposit their eggs. After having spawned once they all die, both males and females alike; none lives to return to salt water. The eggs are deposited in the gravel or on other suitable bottom, usually in the fall of the year, and usually well toward the headwaters of freshwater streams. They hatch in the winter and following spring, but not until some time after the fish that produced them have died. There is a period of a few weeks each year during which each particular salmon family is represented only by a number of eggs. Both parents are dead and none of the children has yet been born; there are only eggs to tide the family over. It is, therefore, evident that no Pacific Coast salmon ever saw either of its parents or any of its children.

After the eggs have hatched the young migrate to the sea, some going down as fry while others remain in freshwater at least one year. In the sea they live and grow rapidly and, when mature, return to freshwater where they spawn and die, thus completing the life-cycle.

The Sockeye or Red Salmon

In the present paper, consideration is given to the Sockeye Salmon only. In order that the recommendations that will be presented may have a proper background of fact, and that they may the more readily be understood and appreciated, it will be well to give in somewhat greater detail some of the more important facts in the life-history of



CASCADES IN LITNIK STREAM, AFOGNAK ISLAND, SHOWING SALMON STRUGGLING IN THE FALLS AND IN THE POOL BELOW. NEAR HERE THE BUREAU OF FISHERIES HAS OPERATED A RED SALMON HATCHERY FOR MANY YEARS WITH UNCERTAIN RESULTS

this very important fish, particularly those wherein it differs from the other species.

The Sockeye enters Only Those Streams that have Lakes in their headwaters

Unlike the other species of salmon, the Sockeye enters only those streams which have one or more lakes somewhere in their course. It ascends such streams to the lakes and spawns either in the shallow water near the shores of the lakes themselves or, more commonly, in the small streams that flow into the lakes. So far as is known, there is no exception to this rule.

Upon reaching the spawning beds, the sockeyes deposit their eggs in the gravel bed of the stream or lake where, more or less deeply covered by the gravel, they remain for several weeks before they hatch. Then the young go down to sea, as fry the first spring after hatching, or they may remain in the lake until the second spring and then go down as yearlings or fingerlings.

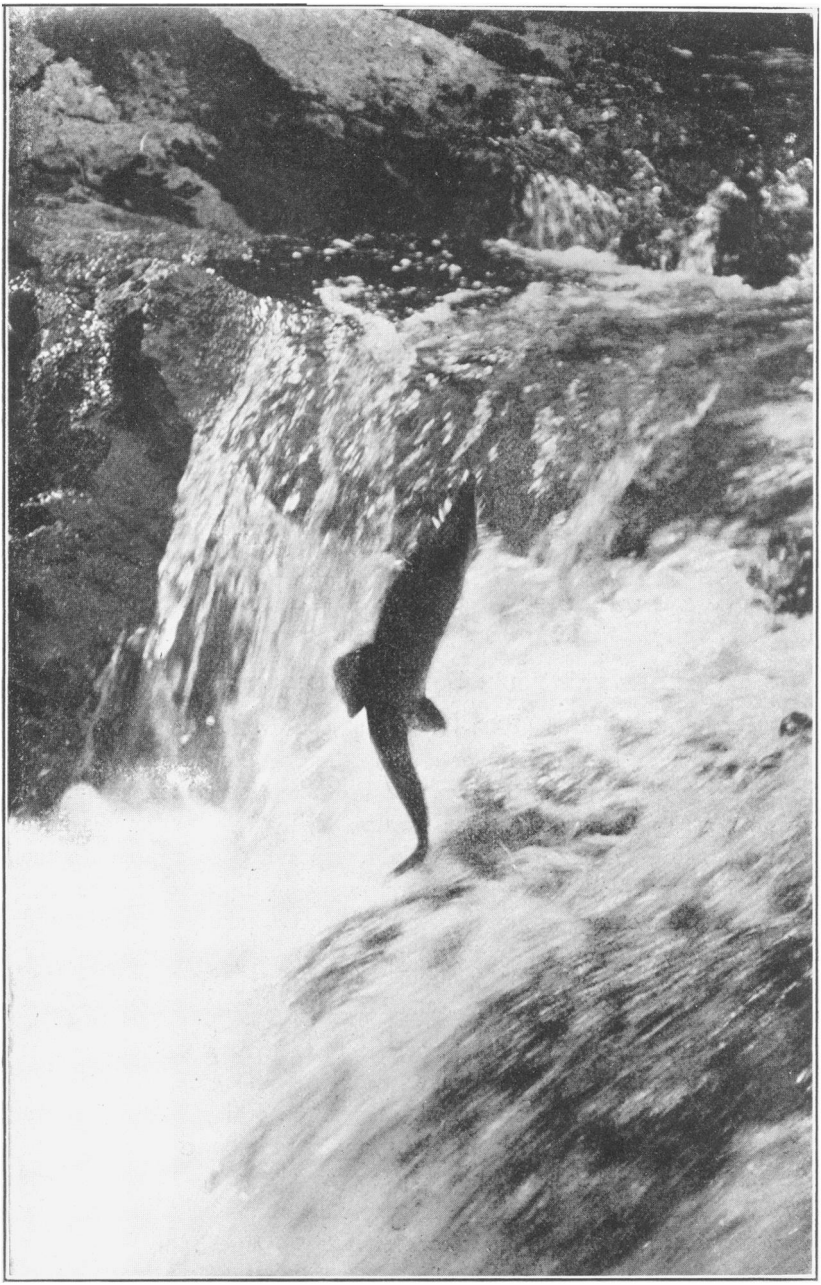
The run of adult sockeyes into freshwater varies considerably in different streams. It may occur at any time from spring until fall. The actual spawning takes place in the late summer or fall. The eggs hatch in the fall, winter, or early spring following.

Age at which the Young Sockeyes Migrate to Salt Water

Chamberlain showed (1903-1905) that Sockeye Salmon fry hatched at the Fortmann hatchery linger a short time on the nursery grounds where liberated, then move down into the lake where they remain a year before going on down to salt water. Gilbert's observations have confirmed those made by Chamberlain, especially as applied to the smaller streams. In the larger rivers, many go down to sea the first spring after hatching, while others remain in the lake until the second spring.

Parent Stream Theory

It has long been maintained by salmon fishermen and others that salmon, when mature, usually, if not invariably, return to the particular stream in which they were hatched. It was generally believed that a great majority of the fish hatched in any particular stream would return to that identical stream when mature and ready to spawn, but that a good many would, or might, go to other streams. Some thought that the salmon return to their own stream because they possess a marvelous geographic or homing instinct, while others maintained that the salmon, after going down to sea as fry or fingerlings, do not wander far from the mouth of the stream in which they were hatched, and that. when they reach maturity they seek freshwater; and the fresh-



A REALLY REMARKABLE PHOTOGRAPH OF A HUMPBACK SALMON ASCENDING THE FALLS IN LITNIK STREAM, AFOGNAK ISLAND

water most easily found is that nearest at hand, which is the water of the stream in which they were hatched; they therefore ascend that particular stream.

While this theory, known as the "Parent Stream Theory," has long been held by many, it was not until recently that its truth was demonstrated. As early as 1906, Chamberlain announced, as one of the conclusions reached from his study of the Sockeye at Naha Stream, Yes Bay and elsewhere in Alaska, that "at least the greater part of the supply of any stream must be derived from the fry produced in that stream."[1]

As one of the results of a long series of investigations and observations requiring infinite patience, as well as the greatest care and skill, Dr. Gilbert has demonstrated the validity of the theory not only in its essential features but even in its minutest details. Gilbert says:[2] "The validity of this important theory has been conclusively demonstrated in the case of the larger rivers of the Province. * * * Examination of the scales has removed any possibility of doubt that the progeny of the Fraser River fish return to the Fraser at their maturity, and that this is true also of the fish of each of the large river-basins. It has now been shown * * * that this same principle holds in the case of all the rivers and creeks, however small these may be, and however near together they may enter the sea."

Gilbert's study of the scales has shown that the salmon of each particular stream possess scale characters in common which enable them to be distinguished from the salmon of any other stream, however near the streams may be to each other. He calls attention to the fact that it is only during their life in freshwater that the salmon are subject to obviously diverse conditions. He further says:[3] "It frequently happens that two lakes belonging to different river systems are separated by a few miles only across a low divide. Their physical conditions, it can not be doubted, in so far as these depend on climate, are practically identical. Yet the sockeyes they produce grow each after its own kind while still in freshwater, and exhibit characteristics of growth and habit which distinguish them from their near neighbors across the divide, and ally them closely with all the other like-colonies of their river-basins, however distant these may be."

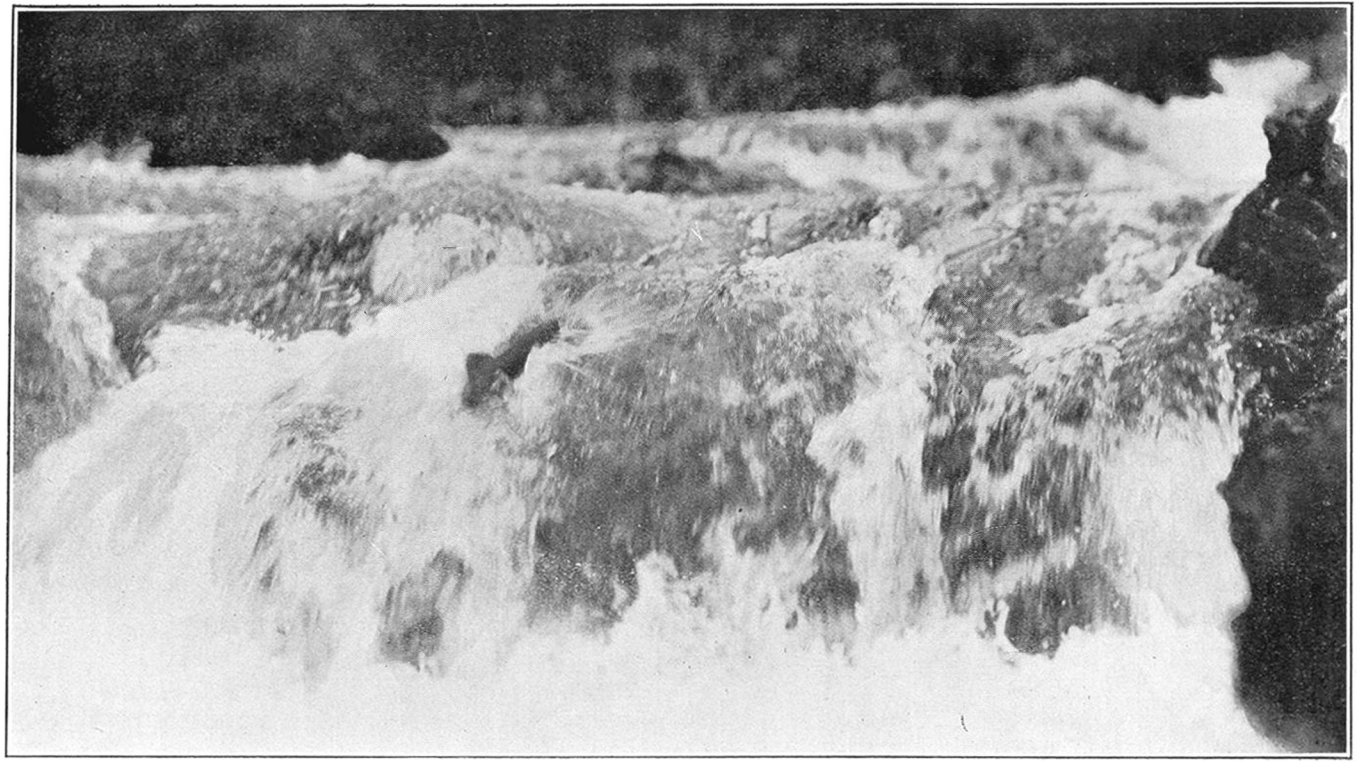
Life-History of Sockeye Salmon as Recorded in Their Scales

The study of the life-history of a salmon, as recorded in its scales, presents one of the most fascinating of stories. There is none more marvelous in all animate nature. Suppose you should take a trip to

[1]Some Observations on Salmon and Trout of Alaska, Bureau Fisheries Doc. 627, 1906 (1907), p. 25.

[2]Contributions to the Life-history of the Sockeye Salmon (Paper No. 3), B. C. Fisheries Department, 1915, p. 527.

[3]Loc. cit., p. 3.



HUMPBACK SALMON ASCENDING IJTNIK FALLS, AFOGNAK ISLAND

British Columbia and Alaska this summer, and while there you should visit some of the great salmon canneries. You have heard somewhere that the age of a salmon can be told from its scales. But you are skeptical. To try the thing out, you cut off a piece of skin with a few scales on it from the side of each of three or four salmon at three or four different canneries. You ask the cannery superintendents from what streams those particular fish came. They tell you and you make a note of it. Numbering the samples for identification, you send them to some expert, Dr. Gilbert, let us say, and ask him to examine them and tell you how old each of the fish was and where it came from. When you get Dr. Gilbert's report you will be surprised. He will tell you not only how old each fish was, but he will tell also the particular stream from which it came, if, perchance, it came from a stream whose salmon he has studied. And he will tell you how long it remained in fresh water before it migrated to the ocean—whether it went down to sea while yet in the fry stage the first spring after hatching, or remained in freshwater a year longer and then went down to sea as a yearling or fingerling. If it remained in the lake one summer and one winter, he will tell you whether the summer was a favorable one as to food supply and other conditions which enabled it to grow rapidly. He will tell you how long it lived in the sea—how many summers and how many winters, and this, of course, added to the time it spent in freshwater before going to sea, will give its age. And, finally, he will tell you what stream this particular salmon was bound for when it was caught. He will be able to learn all these facts regarding each of the specimens you submit to him from an examination of the scales.

Age at which Sockeye Salmon mature

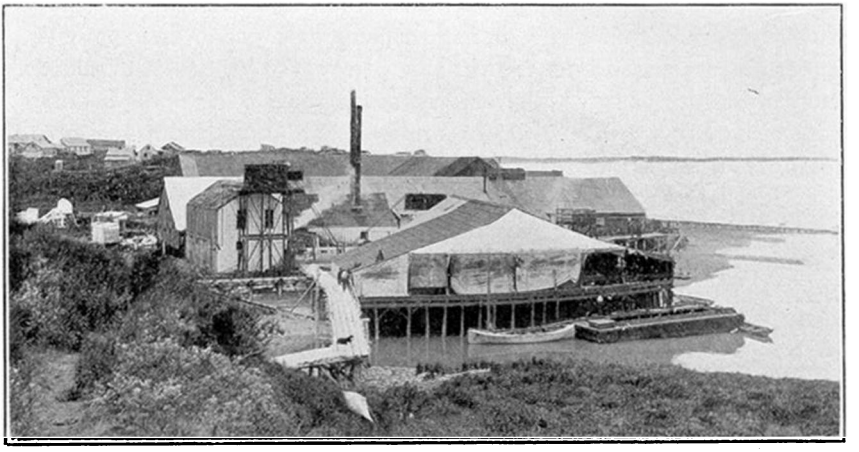
It has been shown by Gilbert that the Alaska and British Columbia sockeyes, as a rule, mature and return to their home streams to deposit their eggs when four years old. A considerable proportion, however, in certain streams, do not return until five years old, and still smaller numbers return at three, six, or even seven years of age. This varies with different streams. For example, it was found that the great majority of the Fraser River sockeyes mature at four years of age, but that, in average years, 10 to 15 per cent. of the run consists of five-year fish. As a result of his study of the sockeyes of Naha Stream, Chamberlain concluded that they are chiefly four-year fish. The Nushagak Bay salmon are either four-year or five-year fish, chiefly the latter.

Attention should here be called to the fact that the salmon return to the stream in which they were liberated when young and in which they were reared through the fry stage or longer. Under natural conditions this, of course, will be the stream in which were laid the eggs

KARLUK HATCHERY, SHOWING RETAINING CORRALS

which produced them. But when eggs taken in one stream, as, for example, the Yes Bay Stream, are hatched and liberated as fry or fingerlings in another, as the Columbia, for example, they will return not to Yes Bay but to the Columbia.

As the adult salmon return to the stream in which they as young were liberated and reared, regardless of whether the eggs from which they were hatched came from fish of that stream or not, it is evident that there is no inherited "homing instinct." They return to the stream in which they, as fry, fed, and not to the stream in which their parents fed when fry, unless it be the same stream. The name "Parent Stream Theory" is not well chosen. "Home Stream Theory" is suggested as a better name.



A TYPICAL WELL-EQUIPPED SALMON CANNERY ON NUSHAGAK BAY. A CANNERY OF THIS TYPE MEANS AN INVESTMENT OF MANY THOUSAND DOLLARS

In view of this important fact, a hatchery which liberates all its output in the stream on which it is located will have no effect upon the run of salmon in any other stream. As Gilbert has said: "In order to maintain the supply of salmon in a given district, it will not be adequate to install a hatchery on any convenient stream into which the entire output of the hatchery will be turned. On the contrary, each stream must be given separate consideration, and must receive its own quota of fry to grow within its boundaries. The original source of the eggs is seemingly a matter of no importance. The destination of the adult salmon is determined by the locality in which the young were reared."[1]

Importance of the Alaska Sockeye Salmon Fisheries

The importance of the Alaska Sockeye Salmon fishery has been very great, as every one knows. As Professor Cobb has said: "Alaska is the most favored salmon-fishing region in the world." The first cannery was erected in 1878 and the first pack was made that year. Other canneries were established from time to time until the number operated in 1918 was 135. The annual pack has varied from 8,159 cases in 1878 to 2,201,643 cases in 1914, when the zenith seems to have been reached. Since 1914 the pack has suffered a great decrease, the pack in 1919 being only 1,204,343 cases. The total pack from 1878 to 1919 reached the enormous total of about forty million cases, as shown by years in tables which have been compiled by Professor Cobb.[1]

Artificial Propagation of the Sockeye Salmon in Alaska

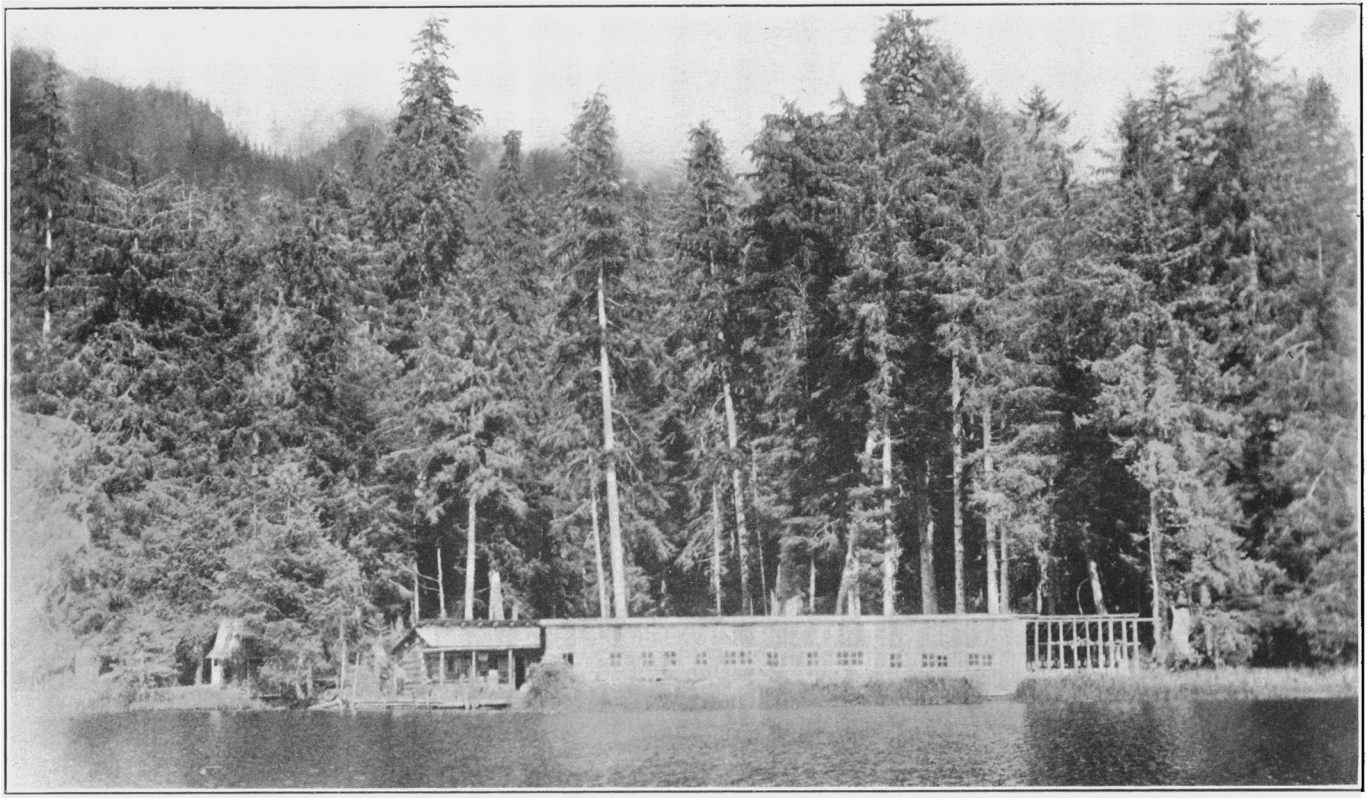
The artificial hatching of salmon in Alaska was begun about thirty years ago. Private hatcheries have been operated at several different places, as at Etolin Island, Karluk, Hetta, Quadra, Freshwater Bay, Kell Bay and Naha. Federal hatcheries are maintained at Yes Bay and at Afognak.

The Callbreath Hatchery

One of the most interesting of these hatcheries was that maintained by Captain Callbreath on Jadjeska Stream, Etolin Island. Captain Callbreath had full faith in the parent stream theory. He believed that, through artificial propagation, he could build up a large annual run of salmon in this small stream. He began in 1893 and continued the experiment until 1905. His method was to catch all the sockeyes ascending this stream, take their eggs and, after hatching, release the fry in the stream.

The experiment was continued for a period of thirteen years. Captain Callbreath, always hopeful, abandoned it only when total

[1]Gilbert, 1915, No. 3, p. s 327.
[1]Report U. S. Fish Commission for 1916, pp. 156-181.



ETOLIN ISLAND RED SALMON HATCHERY WHICH CAPTAIN CALLBREATH OPERATED FOR MANY YEARS IN AN UNSUCCESSFUL ATTEMPT TO ESTABLISH A LARGE RUN OF SALMON IN A STREAM IN WHICH BUT FEW SALMON NATURALLY RAN

blindness and the infirmities of age made it impossible for him to continue longer. He liberated a total of more than 52,000,000 fry. He at first believed the results would show in four years. But there was no increase in the fourth year. Then he expected them in the fifth year, but was again disappointed. Always optimistic, he never lost faith as to the final result. He extended the time to six years, then to seven, then to eight, nine, ten and even longer. The increased run for which he had labored and of which he had dreamed for so many years, never came, and Captain Callbreath died still believing the big runs would begin "next year." Not only did the run in Jadjeska Stream fail to show any increase, it actually diminished. A more pathetic story is not known in all the history of the Alaska salmon fisheries.

The Fortmann Hatchery

The Fortmann hatchery on Naha Stream near Loring, Southeast Alaska, was established by the Alaska Packers Association in 1901, and has been operated each year since. It is the best equipped and largest salmon hatchery in the world, its capacity being over 110,000,000 eggs.

Since the establishment of this hatchery no fishing has been permitted off Naha Stream. The entire run has been permitted to enter the stream and all the fish have been utilized by the hatchery. The fry have been liberated in the lakes of the Naha system. It is assumed that all the eggs that could be obtained were taken; yet, instead of there being an increase in the run, as was expected, there has been a marked decrease. There has been a decided progressive decrease in the number of eggs taken in each of the last three five-year periods, the figures being:

1905-1909	245,674,000
1911-1915	197,580,000
1916-1920	133,980,000

These figures show that the number of eggs taken in the last 5-year period (1916-1920) were less than 56 per cent. of the number taken in the first full 5-year period (1905-1909). Or estimating the egg take of the present year (1920) at the average for the preceding four years, we then have four 5-year periods to compare, and find that the take in the last period is 64 per cent. of that in the first, 51 per cent. of the second, and 70 per cent. of that of the third.

The number of red salmon eggs taken by the various hatcheries totals nearly three billions. If the fish that supplied this enormous number of eggs had been permitted to spawn naturally, the number of eggs they would have produced would doubtless have been much greater, for, in artificial spawning, there is always considerable loss. It is a fair question to ask what would have been the result if these fish had been permitted to spawn naturally?

Statistical tables and other available data, when examined in their relation to each other, ought to throw some light upon the question of the actual value of artificial propagation of the Sockeye Salmon and its relative value as compared with natural reproduction. Unfortunately the records have not been kept with the fullness and accuracy essential to unquestioned conclusions on all phases of the problem, but it would seem that the experiment has been conducted sufficiently long and in a sufficient number of places to warrant the raising of the question as to whether artificial propagation of salmon in Alaska, as conducted, has been more effective in conserving the salmon fisheries than natural reproduction would have been. In answer to the question as to the effect of the Yes Bay hatchery upon the salmon fisheries of Alaska, the U. S. Commissioner of Fisheries replied: "It is difficult to furnish direct evidence of the effects of the [Yes Bay] hatchery operations other than what may be indicated by the statistical figures." Essentially the same reply was given regarding the Afognak hatchery.

In reply to questions as to what increase, if any, has been noted in the catch of salmon in the region with which the Fortmann hatchery is concerned, the Alaska Packers Association replied that no data are available. "We have no data * * * therefore can form no judgment what effect the output of the Fortmann hatchery and the near-by United States Government Yes Bay hatchery may have had upon the supply of salmon of that district."

As to the Karluk hatchery, it is quite certain that none of the millions of fry liberated at that station ever survived to maturity. Although the Karluk run continued large for many years, it was doubtless able to do so because of a considerable annual escape of fish to the spawning beds in and about Karluk Lake where they spawned naturally.

Sockeye Salmon Streams on which Hatcheries have not been operated

There are many Red Salmon streams in Alaska which have not had hatcheries located on them and which, therefore, have not been influenced one way or the other by artificial propagation. Among important streams of this kind that may be mentioned are the Alitak, the Chignik, and the *Nushagak* region. Each of these has supported a great fishery for many years. Although enormous catches were made year after year and although it was felt that the supply must fail sooner or later, there was little decrease for many years. The enormous run in each of these streams depended entirely upon natural reproduction; there was no hatchery on any of them. I have not at hand the figures, but it seems that these streams were able to hold up under natural spawning longer than those streams where artificial propagation was resorted to. It is not claimed that a direct comparison

of the value of natural reproduction as compared with artificial propagation as exhibited by these streams is by any means conclusive, but it is believed such comparison as can be made fails to demonstrate any marked advantage of artificial salmon culture, *as conducted*, over natural methods.

I do not claim for a moment that the artificial propagation of salmon in Alaska must necessarily be less effective than natural reproduction, but I do say that its superiority has not been demonstrated. Indeed, the available evidence would seem to justify the statement that, up to the present, the salmon hatcheries in Alaska have done more harm than good. It would surely be unwise to establish additional hatcheries in Alaska until investigation has shown wherein lies the defect in present methods. The whole question of method in hatchery work and fry planting needs the most careful scientific study by the very best men that can be induced to undertake the solution of this vital problem.

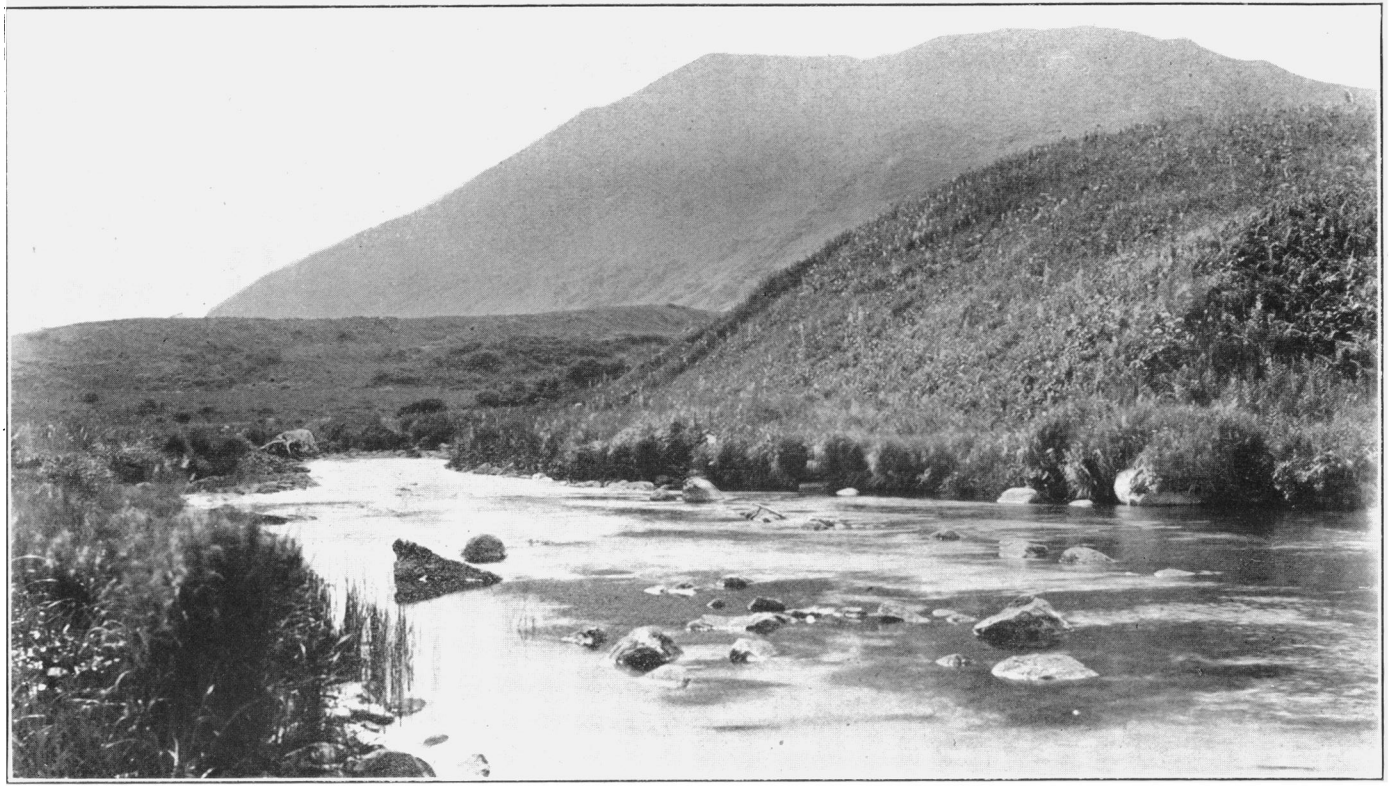
How can the Alaska Salmon Fisheries be saved?

That the Alaska salmon fisheries, as well as those of Puget Sound and Fraser River, are doomed unless something is done and done soon can not be doubted. They have already in some streams reached a condition of depletion so complete that commercial rehabilitation will be possible only with the complete stopping of all fishing for a long period of years. But that this great industry can be saved I have not the slightest doubt.

The knowledge we now have of the life-history of the Sockeye salmon, acquired chiefly through the painstaking investigations and study made by Dr. Gilbert, is adequate for the formulation of a definite plan of investigation which will supply the data which will point the way to a method of conducting the salmon fishery so that we shall not only be able to rehabilitate it but to continue it indefinitely as a going industry with a maximum annual output. Indeed, we can even now say with confidence what the essential features of the plan must be. They are five in number:

1. *Determine the ratio between the number of salmon spawning naturally and the run four (or five) years later.* In other words, determine the number of adult fish which may be expected to return at the end of the four—or five-year—cycle as the result of the natural spawning of a certain number of fish.

   There has been much discussion as to the number of salmon eggs required to produce one adult salmon; in other words, for every salmon that spawns naturally on the spawning beds, how many adult salmon may be expected to return four or five years later?



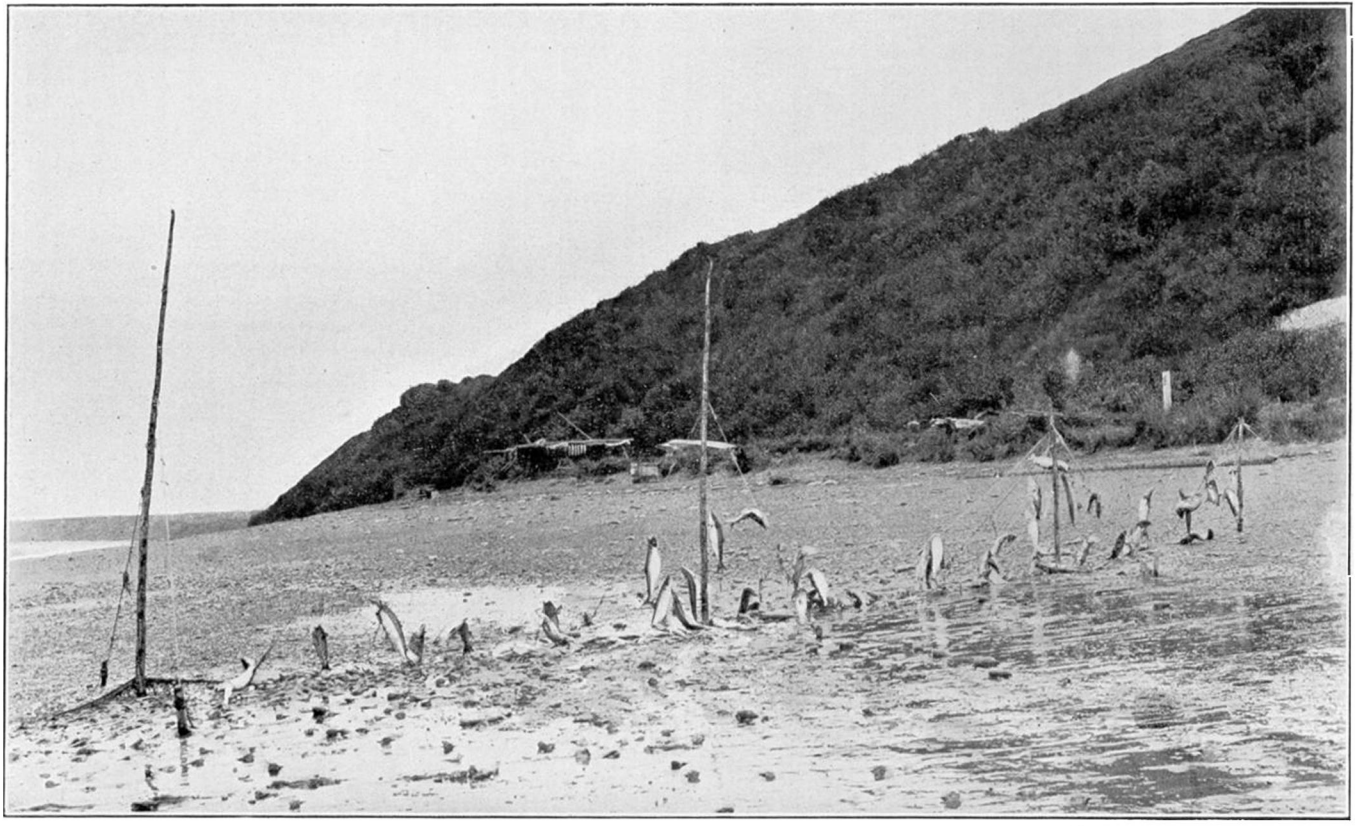
HEAD OF NORTH OLGA STREAM, ALITAK, KODIAK ISLAND; A TYPICAL RED SALMON STREAM

In 1908, the Bureau of Fisheries began a series of observations on a certain stream in Alaska. The observations were known as *The Wood River Investigations*. The present writer had for some years been disposed to believe that, if the run of salmon in a suitable stream could be studied in the proper way for the requisite number of years, the problem could be solved. Wood River in the *Nushagak* region was selected as the stream on which to make the study, and the investigation was begun in the summer of 1908.

A rack was placed across Wood River at the outlet of *Lake Aleknagik* in such a manner as to prevent any salmon from entering the lake except as they were permitted to pass through gates so constructed that they could be opened or closed as desired. A suitable platform or observation station was constructed above the gates from which the observer was able to open or close the gates at will and count the salmon as they passed through. It was found that the fish passed through freely and in an orderly manner, so that an intelligent, conscientious attendant, after a little experience, had no difficulty in keeping an accurate tally. The method was very simple. An actual count was made of the fish passing through in one minute in each fifteen minutes. The number counted in the one minute was assumed to be the average for 15 minutes.

This investigation was carried on every year from 1908 to 1919, both inclusive, except in 1914, when the Secretary of Commerce in his wisdom refused to continue it. He had little or no sympathy with scientific investigation or appreciation of its value. The

A TYPICAL SALMON TRAP NEAR GRAVEYARD POINT, KIRCHAK BAY, SHOWING THE NORTHERN AND INSHORE POT, AS SEEN FROM THE BEACH AT LOW TIDE, THE TUNNEL BEING DOWN



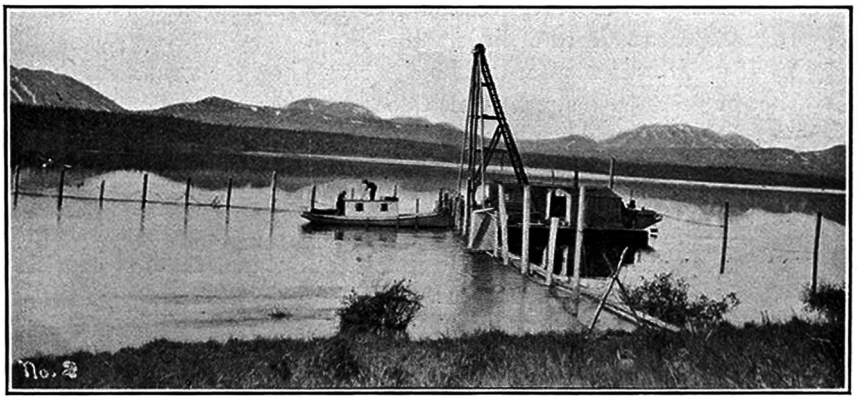
NATIVE METHOD OF USING GILL NETS BETWEEN TIDES ON THE BEACH IN NUSHAGAK BAY

continuity of the investigation was thus broken and the whole experiment rendered of little value.

If an investigation of this kind is carried on for a sufficient number of years on a stream which does not present any complicating conditions which would render the results inconclusive, and, if, during the same years, an accurate record is kept of the fish taken by the canneries from the run of that stream, there would be acquired all the data necessary to answer the question as to how many fish must be permitted to spawn each year in order to provide a certain catch year after year.

When Wood River was selected for the purpose of this experiment, certain difficulties were recognized as existing. Wood River is only one of four streams that enter Nushagak Bay. The other three are the Nushagak, the Egushik, and the Snake. The mouths of these four streams are not far from each other. Each of them receives a part of the Nushagak Bay run. What proportion of the entire run goes to Wood River, and what to each of the other streams no one knows, but it is certain that the Wood River contingent is vastly greater than that of the three other streams combined; indeed, it was thought the run in the Nushagak, Egushik and Snake was relatively so small as to be negliable for the purpose in view. It was believed that a census of the escape in Wood River taken for a series of eight or ten years, compared with the commercial catch for the same series of years, would enable us to arrive at an approximate ratio of escape to catch that would be fairly reliable; in other words, we would know how many fish must spawn in Wood River each year to permit a certain catch four and five years later.

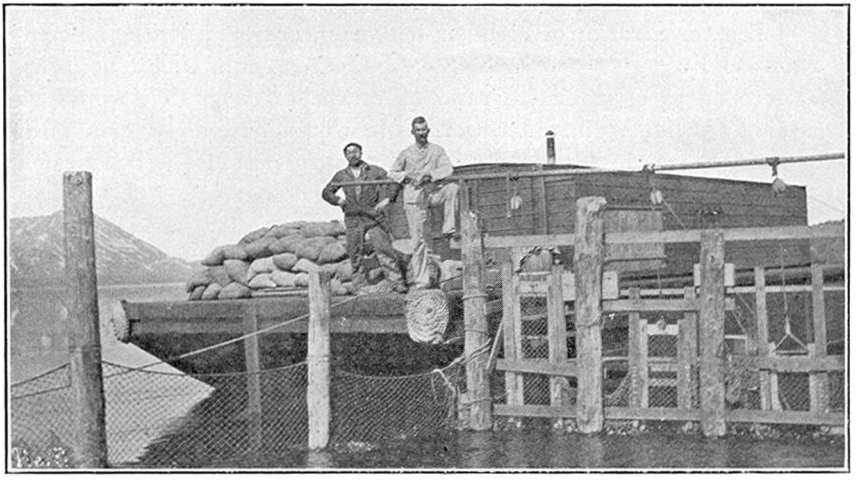
The safety of this assumption may well be questioned. But we know more about the Red Salmon now than was known then. We now know that it is quite practicable to determine the proportional run in each of the four rivers without racking any but Wood River. Dr. Gilbert has shown that salmon return to the particular stream in which they were hatched and that the salmon of any stream are readily distinguished from those of any other stream however close together may be the mouths of the two streams. This being so, it is only necessary to determine what are the distinguishing characters of the salmon of each of the four streams—the Wood, the *Nushagak*, the Egushik and the Snake, then an examination of a considerable number of salmon at each Nushagak Bay cannery for a series of years would enable one to arrive at the percentage of fish of each river in the entire run. The actual escape of Wood River fish is learned by the census, and the percentages obtained at the canneries would enable one to arrive at the escape to each of the other streams.



THE RACK AT LAKE ALEKNAGIK (WOOD RIVER) JULY, 1912

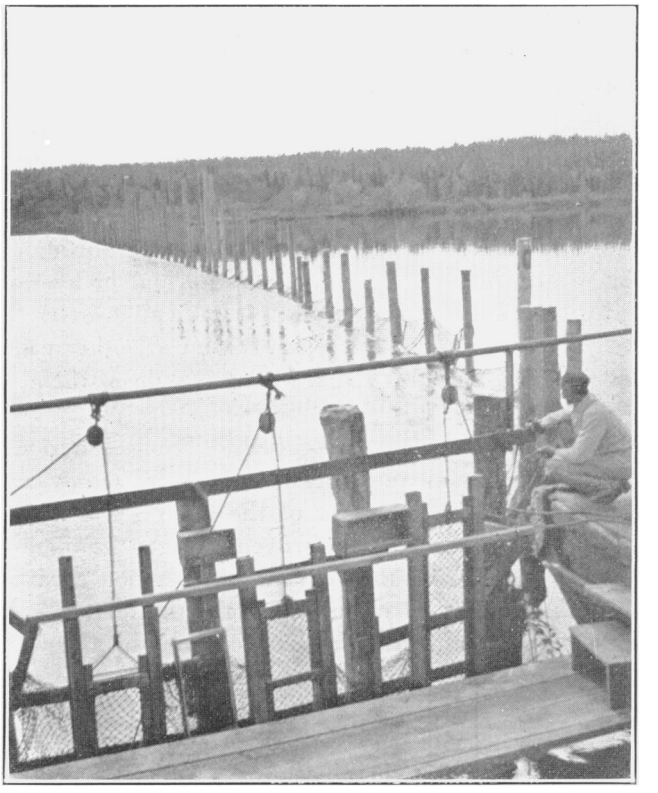
In view of these facts, it seems that Wood River offers an entirely practicable field in which to solve this vitally important problem.

It is realized that the ratio determined for Wood River may not be the proper ratio for any other salmon stream. It will in all probability be necessary to determine the ratio for each particular stream. A census should be made on every red salmon



THE RACK AT LAKE ALEKMAGIK (WOOD RIVER) JULY, 1912

stream possible. There are doubtless some streams on which this investigation can not easily be made, but the great majority of Alaska red salmon streams present no insuperable difficulties, and probably the ratio for all can be determined if the rack is put further up the stream. In any event, the data which can be gotten on the other streams will suggest what to do with those few where it is impracticable to determine the ratio.



COUNTING RED SALMON AS THEY PASS THROUGH THE RACK AT WOOD RIVER, JULY, 1912

2. *Study of the spawning beds.*—The spawning beds in every red salmon stream in Alaska should be carefully studied for the purpose of determining just what conditions are favorable and what unfavorable; what percentage of the eggs are fertilized; what percentage hatches; what percentage of the fry escape all enemies and go down to sea; what the natural enemies are and how destructive each is; whether there is over-crowding of spawning fish, and the result; depth to which the eggs are buried and what the best depth is; food supply for the fry, qualitative and quantitative; and any and all other questions which throw any light on the essential habits of the adults and young when in fresh water. We know practically nothing about the efficiency of natural reproduction of the Sockeye. Fish culturists declare unhesitatingly that a large percentage of the eggs fail of fertilization; that a large percentage of the eggs that do succeed in getting fertilized are lost by being washed away, by being crushed, by being eaten by fishes or other enemies, or by disease of one kind or another; and that of those that do hatch only a small percentage

escape the various enemies that beset them in their fry or fingerling stage, and grow to maturity. All of this in a sense seems reasonable and may be true, but nobody knows; and certainly no convincing proof has been presented. Indeed, the question has never been seriously investigated. The asseverations of the fish-culturists are merely their opinions, supported by scarcely any known facts.

But we should know. We should determine through repeated observation and investigation, what the normal or average loss is from failure in fertilization, from mechanical injuries, from fish and other enemies, from disease, and from all other causes. Else we shall never be able to compare natural with artificial propagation.

3. *Improvement of spawning beds.*—Much can doubtless be done toward improving the spawning beds by removing obstructions, by bettering the character of the gravel, and by increasing the area. It is believed that improvements can be made in many places which will permit the spawning of a much greater number of salmon than now find room or suitable bottom. To know the capacity of any stream it is necessary to know the extent of bottom suitable for spawning beds, whether the beds are utilized to their full capacity, and whether the beds can be improved by enlargement or otherwise. It may well be that, in some streams, the spawning fish are too crowded on parts of the bed while other parts are only partially utilized. It may well be that, by a little work the character of some beds can be improved and that, through removal of obstructions the area of suitable bottom can be greatly increased. It is directly in the interest of the salmon fisheries that every Sockeye salmon stream in Alaska be physically improved to its maximum area of suitable spawning bottom and that, within a margin of safety, spawning fish be permitted to reach those beds to their full capacity.

4. *The life of the young while yet in fresh water.*—As already stated elsewhere in this paper Dr. Gilbert and Mr. Chamberlain discovered that some of the young migrate to salt water in their first spring, others in their second, the proportion varying with different streams and different seasons. While in freshwater the fry may encounter conditions more or less adverse. The food supply may be inadequate, and living enemies such as salmon trout, bullheads, terns, and other birds, and other kinds of fishes, may make serious inroads on their numbers. All these factors should be carefully studied and the conditions improved wherever possible.

5. *Statistics of the run of salmon.*—During the years that the studies outlined above are being made on the streams, statistics of the run of salmon of each stream should be made. The primary object of these studies would be to determine the total number of fish of each particular stream for each of a series of years. If the investigation is properly made, the total run of each stream would be the number of fish headed for that stream taken by the fishermen, plus the escapement as determined by the census at the rack, plus a negligible few that escaped observation. These data, for a series of years would, it is believed, supply a ratio between the number of fish in the escape and the total run which will show the number of fish that must be permitted to escape to the spawning beds to maintain the fishery at a maximum annual pack.

SUMMARY

The essential features of the plan here proposed for the rehabilitation and conservation of the Alaska salmon fisheries may then be summarized as follows:

1. Rack every stream that can be racked and make an accurate count of the salmon ascending it. The census or count must be made often enough to cover at least two returns of each annual run of the first two or three years.
2. In each of the years in which a census of the spawning fish is made, secure statistics showing the number of fish taken by the fisheries from the run of that river. This number plus the escape let through the rack will be the total run of that year. From these data the proper ratio of *escape* to *catch* can be determined.
3. Study each spawning bed and determine its maximum capacity, giving attention at the same time to the possibility of increasing its area and improving the physical and biological conditions thereon.
4. When all has been done in these respects that can be done or need be done, the capacity of the stream and the maximum catch and escape determined—then rack the stream, let through the rack the number of fish which have been found to be necessary to keep up the catch from year to year at the maximum capacity of that stream, close the rack, and then let the commercial fishermen catch in the easiest way they can all the fish that are left.[1] This will probably be by means of haul seines which would most likely be operated immediately below the rack where the fish

[1]Whether all the spawning reserve be passed through the gates before any fishing is permitted, or whether the gates be closed at intervals and "escape" and "catch" alternate through the season, is a matter of detail which, with many others, may properly be left for experimental determination.

would be bunched. All other kinds of gear can then be abandoned—gillnets (fixed and floating), purse-seines, and expensive traps and pounds—all these can be discontinued except in exceptional places.

This would mean a very decided change in the methods of the fisheries and an enormous reduction in the cost. A licensing system similar to that employed in the oyster fisheries of the Atlantic and Gulf coasts, or that of the Federal Government regulating timber-cutting or grazing in national parks and reservations, can be devised and put in operation, satisfactory to the fishery interests.

During the progress of these investigations fishing off the mouths of a good many of the streams will have to be limited; the run in some streams has already been so seriously depleted that it may be wise to prohibit for a number of years all fishing that draws from their run.

The plan here proposed will doubtless meet with strong opposition from the actual fishermen; they will, of course, object to any system which will result in a reduction of the number of fishermen needed to catch the fish. This need not disturb us; the object in view is to maintain the salmon industry as a going concern, not the employment of the greatest possible number of fishermen.

It will also be urged that the investigations required to give us the body of facts essential to the development and application of the method here outlined must necessarily extend through a long series of years and are bound to cost enormously.

This is perfectly true. It will require several years to determine the details of the methods in accordance with which this great fishery must be conducted if it is to live. The cost will be great indeed; perhaps a million dollars, may be more; but what is that in comparison with the untold billions that will in the years to come be the return from the great fishery which the expenditure of a million dollars during the next decade will insure for all time, but which, unless this or something like it is done and done soon, will very soon cease to exist?